JC20 Rec'd PCT/PTO 29 SEP 2005

TURBULENCE BURNER WITH VORTEX STRUCTURES

FIELD OF THE INVENTION

The invention relates to a device and a method of subjecting fuel/air premix to turbulent and vortex air currents to reduce carbon monoxide (CO) and oxides of nitrogen(NOx) emissions.

BRIEF SUMMARY OF THE INVENTION

An object of the invention is to provide a fuel burner that reduces CO and Nox emissions.

Another object of the invention is to subject fuel/air premix to a naturally aspirated pattern of turbulent air having a curvilinear retrogradation and areas of helicoidal vortex currents of air to eliminate CO while further reducing NOx emissions.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention will become more apparent after reading the following detailed description of the preferred embodiment of the invention, given with reference to the accompanying drawings, in which:

Figure 1 shows a front view of a combustion cylinder according to a first embodiment;

Figure 2 shows a front view of a combustion cylinder according to a second embodiment;

Figure 3 shows a front view of a combustion cylinder according to a third embodiment;

Figure 4 shows a top view of the combustion cylinder of Figure 3;

Figure 5 shows a front view of a combustion cylinder according to a fourth embodiment;

Figure 6 shows a top view of the combustion cylinder of Figure 5;

Figure 7 shows a front view of a combustion cylinder according to a fifth embodiment;

Figure 8 shows a top view of the combustion cylinder of Figure 7;

Figure 9 shows a front view of a combustion cylinder according to a sixth embodiment;

Figure 10 shows a top view of the combustion cylinder of Figure 9;

Figures 11 and 12 show the combustion cylinder of Figure 9 rotated 90° and 180°, respectively, with respect to a longitudinal axis of the cylinder;

Figures 13 and 14 illustrate a front and top view, respectively, of a seventh embodiment having a multiple burner head;

Figures 15 and 16 illustrate a modification of the multiple burner head embodiment with the addition of external vortex fins;

Figures 17 and 18 illustrate a front and top view, respectively, of an eighth embodiment with the burner head raised so that the nozzle cap slots 10 are outside the cylindrical air guide; and

Figures 19 and 20 illustrate a front and top view, respectively, of a ninth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A fuel burner as shown in the first embodiment of Figure 1 includes a tubular combustion cylinder 1 open at a first extremity 2 and a second extremity 3. A fuel inlet pipe 5 projects slightly into the combustion cylinder and connects to a hollow air mixer body 6. An orifice 7 communicates from the fuel inlet pipe 5 into the air mixer body 6.

The air mixer body 6 has a proximal end and a distal end. The air mixer body 6 has three primary air inlet holes 8 at the proximal end. One of ordinary skill in the art would recognize that the number and size of such holes may be varied

in relation to the size of the orifice 7. The distal end of the air mixer body 6, farthest from the first extremity 2, terminates in a hemispherical nozzle cap 9. The cap 9 has seven nozzle cap slots 10. The number and area of the slots may be varied by one skilled in the art in relation to the size of the orifice 7 and the primary air inlet holes 8.

Primary ignition of fuel at the nozzle cap slots 10 creates a circular pattern of flame adjacent to an inner wall 4 of the combustion cylinder 1. The combusted fuel discharges at the second extremity 3. Since the air mixer body 6 is positioned at the first extremity 2 of the combustion cylinder 1, an unregulated, turbulent forced air effect develops. In addition, the exterior of the air mixer body 6 and the inner wall 4 together define a secondary area of unregulated, turbulent air for combustion. This turbulent forced air effect increases the pressure at the primary air inlets 8 and reduced CO and NOx emission result.

The air mixer body 6, primary air inlet holes 8 and nozzle cap slots 10 may be referred to in totality as a type of burner head. Commercially engineered burner heads of this type are typically engineered to yield 7,500 British Thermal Units (Btu) at 11 inches water column (w.c.) supply pressure for propane gas in free air burn. The embodiment in Figure 1 permits

an orifice size producing 25,000 Btu at the same supply pressure of propane. As appreciated by one of ordinary skill in the art, reference to propane as a fuel is illustrative without any intent to limit the types of fuel, which may be combusted in this burner with reduced CO and NOx emissions.

Reduced CO and NOx emissions are obtained by each of the embodiments of the invention. The second embodiment shown in Figure 2 illustrates a moveable assemble bracket 11 that is attached to the exterior of the combustion cylinder 1 and the fuel inlet pipe 5. The manner of attachment and movement may vary without limiting the scope of the invention. The bracket 11 is adjustable to enable the air mixer body 6 to be positioned closer to the second extremity 3 of the combustion cylinder 1. When the air mixer body 6 is closer to the second extremity 3, the pressure at the primary air inlet holes 8 increases, so that the resultant combustion reduces CO and NOx emissions even further than in the embodiment of Figure 1.

The third embodiment illustrated in Figure 3 and Figure 4 shows the fuel inlet pipe 5 communicating with the air mixer body 6 through a threaded choke adjuster shaft 12. Figure 4 is a view of the embodiment from the second extremity 3 through the combustion cylinder 1 toward the first extremity 2.

As seen in Figure 3, a choke adjuster disk 13 with mating thread is attached to the choke adjuster shaft 12. The choke adjuster disk 13 creates a venturi effect as it is regulated. Such regulation also varies the degree of turbulence of secondary combustion air. This embodiment can be operated with varying percentages of excess air, typically ranging from 3% to 20% for various applications and at various altitudes of sea level. Regulation of the choke adjuster disk 13 also slows the speed of combustion gas through the combustion cylinder 1, so that CO and NOx emissions are further reduced as compared to the embodiment of Figure 1.

The fourth embodiment as illustrated in Figure 5 and Figure 6 shows a turbulence disk 14 attached to the exterior of the air mixer body 6. Figure 6, similarly to Figure 4 is a view of the embodiment from the second extremity 3 through the combustion cylinder 1 toward the first extremity 2. In this embodiment, two different zones of air pressure in the regulated turbulent secondary combustion air develop after primary ignition. One zone is above and one below the turbulence disk 14.

In the embodiment of Figures 5 and 6, a pattern of turbulence with a curvilinear retrogradation develops in the secondary combustion air upstream of the ignition area of the

nozzle cap slots 10. Although the pattern of turbulence occurs, flame stability is maintained. In addition, positive pressure at the primary air inlet holes 8 is increased and a negative pressure develops at the nozzle cap slots 10. These changes in pressure improve flame lift-off above the nozzle cap slots 10, so that CO is practically eliminated while NOx emission is maintained at a reduced level.

The fifth embodiment as illustrated in Figure 7 and Figure 8 shows a hollow cylindrical air guide 15 attached to the fuel inlet pipe 5 terminating closest to the second extremity 3 in an air guide aperture 16, with Figure 8 being a same view as Figures 4 and 6 as noted above. The exterior of the air mixer body 6 and interior of the cylindrical air guide 15 define an area of secondary combustion. The interior of the cylindrical air guide 15 confines the pattern of turbulence in the secondary combustion air at the ignition area of the nozzle cap slots 10, so that the pressure increases further at the primary air inlet holes 8 resulting in further reduction of Nox emission, while CO is still practically eliminated.

The sixth embodiment as illustrated in Figures 9 and 10 shows a confined cylindrical air guide aperture 16, with Figure 10 being the same view as Figure 8 in the fifth embodiment. Several vortex fins 17 project into the air guide

aperture 16 closer to the second extremity 3. Vortex slots 18 fill the interstices between the vortex fins 17. The force of the naturally aspirated rising air through the vortex slots creates an area of helicoidal vortex air currents in the secondary combustion air. The low-flow velocities of vortex air currents in this area further entrain the fuel-air premix and improve combustion. As a consequence, CO emissions remain practically eliminated (as in the prior embodiment), yet NOx emissions are further reduced.

Figures 11 and 12 completely illustrate the sixth embodiment of Figure 9 with the view of Figure 11 rotated 90 degrees on the vertical axis. These views are included to more clearly show that air guide 15 is hollow and includes an opening closer to the first extremity 2.

One skilled in the art may of course proportionately scale the various orifices, interstices and structures to increase or decrease the amount of input fuel and resulting output Btu power.

Figures 13 and 14 illustrate a multiple burner head of the seventh embodiment. Figure 14 is the same view as Figure 10 of the prior embodiment. As seen in Figure 13, a lower fuel feed fixture 11B and an upper fuel feed fixture 11C are attach to a fuel feed bracket 11A. The amount of excess combustion air in

this embodiment can also be adjusted. Intake holes in an upper choke disk 13A are aligned through rotation over the intake holes in a lower choke disk 13B. As illustrated the intake holes are fully aligned and opened.

Figure 15 and Figure 16 illustrate the seventh embodiment with the addition of external vortex fins 19. Figure 16 is the same view as Figure 14 of the prior embodiment. The external vortex fins 19 protrude into a tertiary combustion air flow between the outside of the cylindrical air guide 15 and the combustion cylinder inner wall 4. A further complimentary area of helicoidal vortex currents result in the cooler tertiary combustion air. Lower combustion temperature further reduces NOx emission.

Figure 17 and Figure 18 illustrate an eighth embodiment with the burner head raised in the cylindrical air guide 15 such that the nozzle cap slots 10 are closer to the second extremity 3 and outside the cylindrical air guide 15, with Figure 18 being the same view as Figure 16 of the prior embodiment. In this embodiment, the flame thereby spreads wider in closer proximity to the combustion cylinder inner wall 4. Flame entrainment with the slower and cooler airflow velocities of the helicoidal vortex currents in the tertiary combustion air further minimize NOx emissions.

Figures 19 and 20 illustrate a ninth embodiment of the invention. In this embodiment, similar to the embodiment of Figures 17 and 18, the nozzle cap extends beyond the cylindrical air guide 15. However, in the ninth embodiment, the nozzle cap slots of Figure 18 are replaced by a plurality of nozzle cap holes 21. In addition, the nozzle cap 9′ is conical instead of hemispherical. The nozzle cap 9′ has a nozzle cap lip 20 that protrudes from the air mixer body 6. The nozzle cap lip 20 produces a pattern of turbulence with a curvilinear retrogradation without the addition of a turbulence disk 14 to the air mixer body 6.

In each of the embodiments of the invention, NOx reduction is achieved without use of devices such as laterally injected combustion air forming a secondary torroidal recirculation zone in the combustion cylinder 1 further downstream of the primary combustion area. In addition, CO emissions are practically eliminated.

While the present invention has been described in connection with various preferred embodiments thereof, it is to be understood that those embodiments are provided merely to illustrate the invention, and should not be used as a pretext to limit the scope of protection conferred by the true scope and spirit of the appended claims.